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Key to the lichen families *Pyrenulaceae* and *Trypetheliaceae* in Vietnam, with eight new records

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Abstract—An identification key is presented for the members of the lichen families *Pyrenulaceae* and *Trypetheliaceae* in Vietnam. Eight pyrenocarpous species (in *Anthracothecium*, *Astrothelium*, *Lithothelium*, and *Pyrenula*) collected from Nam Cat Tien National Park, are new records for Vietnam. Taxonomic characters of the species are given along with ecology, distribution, and illustrations.

Key words—*Bathelium*, *Nigrovothelium*, taxonomy, *Trypethelium*

Introduction

Pyrenocarpous lichens in the tropics belong mainly to the families *Porinaceae*, *Pyrenulaceae*, *Strigulaceae*, and *Trypetheliaceae* and are among the major constituents of epiphytic lichen communities in primary rain forests (Aptroot 2009). Although little remains of Vietnam's primary forests, the protected areas, reserve forests, and national parks still conserve significant stretches of old-growth rain forests, particularly in the southern part of the country. The present inventory is the result of ongoing research conducted in Nam Cat Tien National Park situated in southern Vietnam and provides new records of eight pyrenocarpous lichens in *Trypetheliaceae* and *Pyrenulaceae* for Vietnam. Both families have been the focus of increasing global interest in recent years. Currently, 234 species in 11 genera are accepted in *Pyrenulaceae*, and 418 species in 15 genera in *Trypetheliaceae* (Aptroot 2012, Aptroot & Lücking 2016, Lücking et al. 2016). From Vietnam 24 species of *Pyrenulaceae* have been

recorded: *Anthracothecium macrosporum* (Hepp) Müll. Arg., *A. prasinum* (Eschw.) R.C. Harris; *Pyrenula aggregata* (Fée) Fée, *P. anomala* (Ach.) Vain., *P. aspistea* (Ach.) Ach., *P. balia* (Kremp.) R.C. Harris, *P. breutelii* (Müll. Arg.) Aptroot, *P. brunnea* Fée, *P. duplicans* (Nyl.) Aptroot, *P. fetivica* (Kremp.) Müll. Arg., *P. mamillana* (Ach.) Trevis., *P. massariospora* (Starbäck) R.C. Harris, *P. microcarpa* Müll. Arg., *P. nitidella* (Schaer.) Müll. Arg., *P. nitidula* (Bres.) R.C. Harris, *P. ochraceoflava* (Nyl.) R.C. Harris, *P. parvinuclea* (Meyen & Flot.) Aptroot, *P. pyrenuloides* (Mont.) R.C. Harris, *P. quassiicola* (Fée) Fée, *P. scutata* (Stirt.) Zahlbr., *P. sexlocularis* (Nyl.) Müll. Arg., *P. subglabrata* (Nyl.) Müll. Arg., *P. sublaevigata* (Patw. & Makhija) Upreti, *P. thelemorpha* Tuck.—while 16 species have been recorded in *Trypetheliaceae: Astrothelium aeneum* (Eschw.) Aptroot & Lücking, *A. cinnamomeum* (Eschw.) Müll. Arg., *A. clypeatum* Aptroot & Gueidan, *A. megaspermum* (Mont.) Aptroot & Lücking, *A. nitidiusculum* (Nyl.) Aptroot & Lücking, *A. phlyctaena* (Fée) Aptroot & Lücking [= *Trypethelium ochroleucum* (Eschw.) Nyl.], *A. porosum* (Ach.) Aptroot & Lücking, *A. variolosum* (Ach.) Müll. Arg.; *Bathelium albidoporum* (Makhija & Patw.) R.C. Harris, *B. lineare* (C.W. Dodge) R.C. Harris, *B. porinosporum* Lücking et al.; *Nigrovothelium tropicum* (Ach.) Lücking et al.; *Trypethelium eluteriae* Spreng., *T. epileucodes* Nyl., *T. infraeluteriae* Aptroot & Gueidan, *T. krempelhuberi* Makhija & Patw. (Aptroot & Sparrius 2006, Aptroot 2012, Aptroot et al. 2016, Lücking et al. 2016).

In addition to some previously reported species, we examined some interesting pyrenocarpous lichens that we report here as new Vietnamese records: *Anthracothecium interlatens*, *Astrothelium galligenum*, *A. inspersogalbineum*, *A. subaequans*, *Lithothelium obtectum*, *Pyrenula circumfiniens*, *P. laetior*, and *P. mastophora*. An artificial key to all known species in Vietnam representing *Pyrenulaceae* and *Trypetheliaceae* is also presented.

Materials & methods

The Vietnamese material was collected by Dr. J.-S. Hur and J.J. Woo in December 2015 from the lowland areas in southern Vietnam having warm and humid preserved forests with a sub-oceanic climate. The material was deposited in the lichen herbarium of the Korean Lichen Research Institute, Suncheon, South Korea (KoLRI), and studied in the Lichenology laboratory of CSIR-National Botanical Research Institute, Lucknow, India. The morphological characters were identified and measured using a MSZ-TR dissecting microscope and a Leica DM 500 compound microscope. Standard protocols were followed to analyse chemistry (Orange et al. 2010). Amyloidity (I+ or I–) of internal structures was tested using Lugol's solution. Images were taken using a Zeiss Axiocam ERc5s and A1(AX10) microscope. The key includes some characters that

were not apparent in our specimens but were derived mainly from Upreti (1991, 1998), Aptroot et al. (2008), Aptroot (2012), and Aptroot & Lücking (2016).

Taxonomy

Anthracothecium interlatens (Nyl.) Aptroot, Lichenologist 44: 35, 2012. Pl. 1a

Thallus epi- to endoperidermal, pale green to fawn, corticate, continuous, matt to slightly glossy, reflecting bark texture, delimited by blackish prothallus, 100–120 µm thick; cortex 50–60 µm thick; photobiont trentepohlioid, layer distinct, ≤50 µm thick; medulla not apparent; perithecia semi-immersed to emergent, black, scattered to aggregate with shared ostiole, 0.5–0.7 mm in diam.; perithecial wall complete, carbonized, 45–80 µm thick; ostiole apical, 0.071–0.1 mm in diam; hamathecium hyaline, clear, with unbranched filaments; asci 2-spored, 200–230 × 45–52 µm, I–; ascospores mostly hyaline to grayish at maturity, oblong to slightly curved, muriform, 100–132 × 32–42 µm, I–.

Chemistry—No lichen substances present.

Distribution & ecology—Pantropical (Aptroot 2012). In Vietnam, the species was found growing in association with *Ocellularia* spp. in irregular patches on uneven bark surfaces.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Cat Tien National Park, forest red soil area, 11°24′20″N 107°17′19″E, alt. 256 m, on bark, 17 December 2015, Hur & Woo VN150006 (KoLRI).

Remarks—*Anthracothecium gregale* (C. Knight) Aptroot is morphologically close but produces 6–8-spored asci (Aptroot 2012). Only a small amount of *A. interlatens* was collected in only a small amount from the national park, but the Vietnamese specimen was easily identifiable.

Astrothelium galligenum (Aptroot) Aptroot & Lücking, Lichenologist 48: 861, 2016. Pl. 1b

Thallus epiperidermal, pale greenish gray to greenish gray, smooth, continuous, glossy, delimited by blackish prothallus, ≤180 µm thick; cortex distinct, continuous, 50–60 µm thick; photobiont trentepohlioid, layer distinct, continuous, 40–50 µm thick; medulla white crystalline, reaching ≤70 µm; ascomata immersed to slightly emergent, trypethelioid, scattered, solitary to slightly confluent, 0.2–0.3 mm in diam., pseudostromatic; pseudostromata off-white, irregular in shape; ostiole apical, black, 0.01–0.03 mm in diam.; perithecial wall complete, carbonized, 90–100 µm thick hamathecium hyaline, inspersed with oil droplets, with anastomosing filaments; asci 8-spored, 140–170 × 20–30 µm, I–; ascospores uni- to biseriate, fusiform, hyaline, transversely 7–8-septate with diamond shaped lumina, 40–47 × 10–12 µm, I–.

Chemistry—Thallus and ascomata UV–, hamathecium oil droplets K+ purple; anthraquinone present.

Distribution & ecology—Eastern Palaeotropics (Aptroot & Lücking 2016). This species is apparently rare in the national park, where it was growing in association with *Bathelium mastoideum* and *Sarcographa* spp. on trees with somewhat undulating thick smooth bark.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, in forest red soil area, 11°23′49″N 107°17′38″E, alt. 206 m, on bark, 17 December 2015, Hur & Woo VN150125 (KoLRI).

Remarks—*Astrothelium ubianense* (Vain.) Aptroot & Lücking is similar, but has a clear hamathecium and lacks anthraquinone (Aptroot & Lücking 2016).

Astrothelium inspersogalbineum Aptroot & Weerakoon, Lichenologist 48: 618, 2016. Pl. 1c

Thallus epiperidermal, greenish gray to yellowish green, smooth, continuous, glossy, delimited by blackish prothallus, 100–150 µm thick; cortex distinct, 30–40 µm thick photobiont trentepohlioid, layer distinct, continuous, 50–60 µm thick; medulla endoperidermal; ascomata emergent, trypethelioid, scattered, solitary to slightly aggregate then open by a common ostiole, mostly covered by thallus, 0.6–0.7 mm in diam.; ostiole apical to slightly eccentric, black, 0.08–0.1 mm in diam.; perithecial wall complete, carbonized, 100–150 µm thick laterally, reaching ≤350 µm basally; hamathecium hyaline, inspersed with oil droplets, with anastomosing filaments, placed deep into the ascomata; asci 8-spored, 40–50 × 10–12 µm, I–; ascospores mostly uniseriate, fusiform, hyaline, transversely 3-septate with diamond shaped lumina, 20–22 × 7–9 µm, I–.

Chemistry—Thallus and ascomata UV+ yellow, K+ purple; lichexanthone and anthraquinone present.

Distribution & ecology—This is only the second report of this taxon, originally described from Singapore (Aptroot et al. 2016). In Vietnam, it was growing luxuriantly in association with *Bathelium mastoideum* on thick smooth-barked trees.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, in forest red soil area, 11°23′36″N 107°17′56″E, alt. 181 m, on bark, 17 December 2015, Hur & Woo VN150126 (KoLRI).

Remarks—This species is close to *Astrothelium macrocarpum* (Fée) Aptroot & Lücking, which differs in its clear hymenium and pseudostromatic ascomata (Aptroot 2012). Our Vietnamese *A. inspersogalbineum* specimen,

with a K+ purplish thallus, differs slightly from the K– holotype (Aptroot & Lücking 2016).

Astrothelium subaequans Müll. Arg., Bot. Jahrb. Syst. 6: 383, 1885. Pl. 1d

Thallus epiperidermal, olive green, bullate, uneven, hard, continuous, dull to ± glossy, delimited by blackish prothallus, 200–300 µm thick, photobiont trentepohlioid, layer distinct, continuous, 40–50 µm thick; medulla white, crystalline, 200–350 µm thick; ascomata astrothelioid, scattered, solitary to aggregate and pseudostromatic, covered by thallus, surrounded by yellow-orange pigments, 0.7–1 mm in diam.; ostiole slightly eccentric, black, 0.5–0.1 mm in diam.; perithecial wall complete, carbonized, laterally 100–130 µm thick and basally reaching ≤600 µm, separated from the thallus by a slit; hamathecium hyaline, clear with anastomosing filaments, placed deep into the ascomata; asci 8-spored, 145–155 × 40–47 µm, I–; ascospores biseriate, oval, hyaline, muriform, 60–65 × 18–21 µm, I–.

Chemistry—Thallus UV–, ascomata UV+ reddish, pigment K+ purple; anthraquinone present.

Distribution & ecology—Previously known from the Neotropics (Aptroot 2016). In Vietnam, the species was growing richly in large patches on trees with thick and hard bark.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, in forest red soil area, 11°24′20″N 107°17′19″E, alt. 256 m, on bark, 17 December 2015, Hur & Woo VN150054 (KoLRI).

Remarks—This species is close to *Astrothelium praetervisum* (Müll. Arg.) Aptroot & Lücking, which differs in producing pseudostromatic ascomata (Aptroot & Lücking 2016). Our Vietnamese *A. subaequans* specimen is characterized by distinctly muriform ascospores that differ slightly from the submuriform ascospores described by Aptroot & Lücking (2016).

Lithothelium obtectum (Müll. Arg.) Aptroot, Biblioth. Lichenol. 44: 62, 1991. Pl. 1e

Thallus epiperidermal, grayish green, corticate, continuous, dull to slightly glossy, delimited by black prothallus, ≤100 µm thick; cortex 20–30 µm thick; photobiont trentepohlioid, layer 40–50 µm thick; medulla not apparent; perithecia emergent, black, irregularly in shape to shortly elongate, numerous, solitary to aggregated in groups of 2–3 joint together with fused ostiole, 0.2–0.7 mm long; ostiole eccentric to laterally placed, 0.05–0.1 mm in diam.; perithecial wall complete, carbonized, 90–100 µm thick; hamathecium hyaline, clear, with unbranched filaments; asci 8-spored, 60–90 × 8–12 µm,

I–; ascospores uniseriate, fusiform, hyaline, transversely 3-septate, 10–15 × 3–4 µm, I–.

Chemistry—No lichen substances present.

Distribution & ecology—Pantropical (Aptroot et al. 2008). In Vietnam, the species was collected from hard, rather rough-barked trees, where it was growing luxuriantly with crustose lichen taxa, probably *Graphidaceae*.

Specimens examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, near Crocodile lake, 11°27′25″N 107°21′4″E, alt. 156 m, on bark, 19 December 2015, Hur & Woo VN150400, VN150402 (KoLRI).

Remarks—The examined specimen differs from the type of *Sagedia obtecta* Müll. Arg. (especially in thallus formation and number of fused ascomata). It is possible that the ecorticate thin thallus and solitary ascomata describing the type are features taken from a damaged specimen with an eroded thallus. *Lithothelium decumbens* (Müll. Arg.) Aptroot is close to *L. obtectum* but differs in producing brown ascospores (Aptroot 2012).

Pyrenula circumfiniens Vain.,
Ann. Acad. Sci. Fenn., Ser. A, 6(7): 195, 1915. Pl. 1f

Thallus epiperidermal, olive green to dark green, corticate, continuous, glossy, delimited by black prothallus, 100–150 µm thick; cortex 40–60 µm thick; photobiont trentepohlioid, layer 50–70 µm thick; medulla not apparent; perithecia semi-immersed, black, numerous, solitary to sometimes aggregated in 2–3 groups, 0.3–0.5 mm in diam.; ostiole eccentric to laterally placed in different directions, 0.01–0.2 mm in diam.; perithecial wall complete, carbonized, 90–100 µm thick; hamathecium hyaline, clear, with unbranched filaments; asci 8-spored, 60–90 × 8–12 µm, I–; ascospores uniseriate, fusiform, gray brown, transversely 3-septate, terminal lumina directly against the exospores wall, 13–18 × 4–6 µm, I–.

Chemistry—No lichen substances present.

Distribution & ecology—Pantropical (Aptroot 2012). In Vietnam, *Pyrenula circumfiniens* was flourishing well around trees having wide girth. The species was spread largely in irregular patches and intermingled marginally with other pyrenocarpous lichens.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, near rock stream, 11°26′39″N 107°24′22″E, alt. 160 m on bark, 18 December 2015, Hur & Woo VN150250 (KoLRI).

Remarks—The ascospore sizes in our sample are somewhat close to those in *Pyrenula elliptica* Müll. Arg., which is distinguished by its slightly larger (15–18 × 6–8 µm) ascospores and distribution restricted to the Neotropics (Aptroot 2012).

Pyrenula laetior Müll. Arg., Bot. Jahrb. Syst. 6: 413, 1885. Pl. 1G

Thallus epi- to endoperidermal, brownish green to reddish brown, corticate, continuous, ± dull, delimited by black prothallus, ≤100 µm thick; cortex 20–25 µm thick; photobiont trentepohlioid, layer ≤30 µm thick; medulla indistinct, mostly endoperidermal; perithecia semi-emergent, black, numerous, simple to aggregate, 0.2–0.3 mm in diam.; ostiole apical, 0.05–0.07 mm in diam.; perithecial wall complete, carbonized, 50–80 µm thick; hamathecium hyaline, inspersed with oil droplets, with unbranched filaments; asci 8-spored, 40–60 × 8–6 µm, I–; ascospores uniseriate, fusiform, gray brown, transversely 3-septate, terminal lumina separated from the exospore wall by endospore thickening,13–15 × 4–6 µm, I–.

Chemistry—No lichen substances present.

Distribution & ecology—Previously known from the Neotropics (Aptroot 2012). In Vietnam, the species is found on thin papery bark flaking away from tree trunks.

Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Cat Tien National Park, forest red soil area, 11°24′23″N 107°17′40″E, alt. 288 m, on bark, 17 December 2015, Hur & Woo VN150083 (KoLRI).

Remarks—*Pyrenula subglabrata*, previously reported from Vietnam, is morphologically similar to *P. laetior* but can be distinguished by its longer (18–20 µm) ascospores (Aptroot 2012). Our material, which produces very short (≤15 µm) ascospores fits well within the range of the new world *Pyrenula laetior*.

Pyrenula mastophora (Nyl.) Müll. Arg., Flora 66: 426, 1883. Pl. 1H

Thallus epiperidermal, green to grayish green, corticate, continuous, smooth, delimited by a black prothallus, ≤150 µm thick; cortex 35–40 µm thick; photobiont trentepohlioid, layer ≤45 µm thick; medulla indistinct; perithecia semi-immersed to semi-emergent, initially covered by thallus, black, numerous, scattered, 0.5–0.8 mm in diam.; ostiole apical, indistinct to 0.5 mm in diam.; perithecial wall complete, carbonized, 60–90 µm thick; hamathecium hyaline, clear, with unbranched filaments; asci 8-spored, 150–160 × 20–26 µm, I–; ascospores mostly uniseriate, fusiform, gray brown, transversely 3-septate, terminal lumina separated from the exospore wall by endospore thickening, 28–32 × 11–13 µm, I–.

Chemistry—No lichen substances present.

Distribution & ecology—Pantropical (Aptroot 2012). The Vietnamese specimen broadly colonized on trees with thick smooth bark.

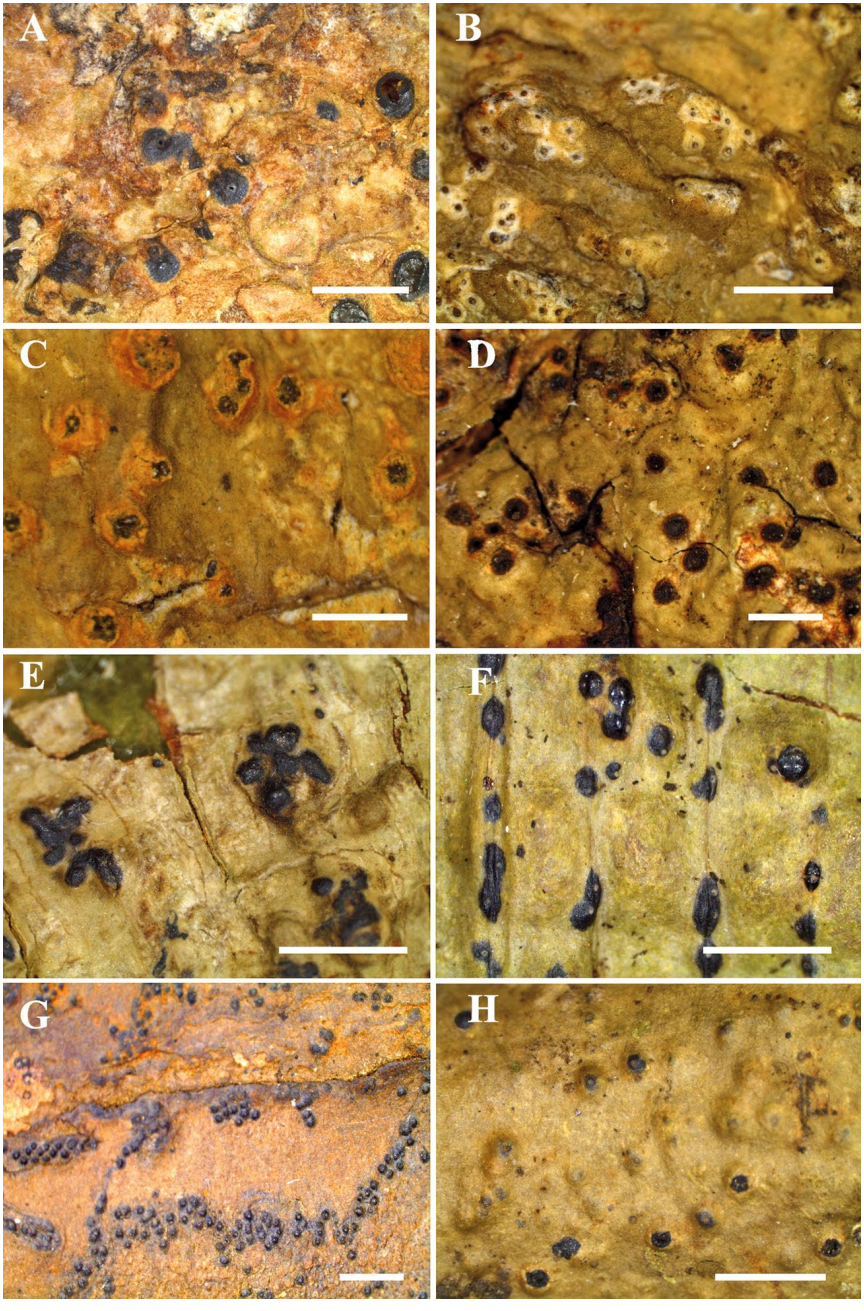
Specimen examined: **VIETNAM. Dong Nai Province: Tan Phu district**, Nam Cat Tien National Park, near rock stream, 11°26′35″N 107°24′19″E, alt. 150 m on bark, 18 December 2015, Hur & Woo VN150216 (KoLRI).

Remarks—*Pyrenula quassiicola* is similar but is distinguished from *P. mastophora* by its partly immersed perithecia and thallus producing pseudocyphellae (Aptroot 2012).

Key to species in *Pyrenulaceae and Trypetheliaceae* recorded from Vietnam

1. Ascospores hyaline 2
1. Ascospores pigmented 21
2. Ascospores transversely septate 3
2. Ascospores muriform 19
3. Ascospore lumina rectangular to oval at maturity 4
3. Ascospore lumina diamond-shaped 10
4. Ascospores 3-septate, 10–15 × 3–4 µm; ostiole lateral ..... ***Lithothelium obtectum***
4. Ascospores >3-septate; ostiole apical 5
5. Ascomata solitary to irregularly confluent 6
5. Ascomata pseudostromatic 7
6. Ostiole usually white pruinose; ascospores transversely 5–7-septate, 25–32 × 6–9 µm ..... ***Bathelium albidoporum***
6. Ostiole non-pruinose; ascospores transversely 3–5-septate, 20–30 × 6–7 µm ..... ***Bathelium porinosporum***
7. Pseudostromata lacking anthraquinone (all white with small dark ostiole spots; ascospores 5–13-septate, 30–60 × 5–13 µm) ..... ***Trypethelium epileucodes***
7. Pseudostromata with anthraquinone 8
8. Ostiolar area broad, disc shaped with margins producing black papillae arranged in circular shapes (ascospores 13–15-septate, 59–72 × 13–15 µm) .... ***Trypethelium krempelhuberi***
8. Ostiolar area narrow, visible as small dots 9
9. Pseudostromata immersed to erumpent; ascospores 7–9-septate, 37–42 × 9–11 µm ..... ***Trypethelium infraeluteriae***
9. Pseudostromata prominent to sessile; ascospores 9–13-septate, 37–52 × 8–11 µm ..... ***Trypethelium eluteriae***

Plate. 1. Specimens of pyrenocarpous lichens from Vietnam. A. *Anthracothecium interlatens* (KoLRI VN150006); B. *Astrothelium galligenum* (KoLRI VN150125); C. *A. inspersogalbineum* (KoLRI VN150126); D. *A. subaequans* (KoLRI VN150054); E. *Lithothelium obtectum* (KoLRI VN150400); F. *Pyrenula circumfiniens* (KoLRI VN150250); G. *P. laetior* (KoLRI VN150083); H. *P. mastophora* (KoLRI VN150216). Scale bars: 1 mm.


A
B
C
D
E
F
G
H

10. Ascospores 7–8-septate (40–47 × 10–12 µm) ..... ***Astrothelium galligenum***
10. Ascospores 3-septate 11
11. Hamathecium inspersed with oil droplets 12
11. Hamathecium clear 14
12. Ostiole lateral (ascospores 20–22 × 7–9 µm; anthraquinone and lichexanthone present) .... ***Astrothelium inspersogalbineum***
12. Ostiole apical 13
13. Ascomata solitary; ascospores 17–27 × 7–10 µm; anthraquinone and lichexanthone both absent ..... ***Astrothelium clypeatum***
13. Ascomata diffusely pseudostromatic; ascospores 17–27 × 7–10 µm; anthraquinone present, lichexanthone absent ..... ***Astrothelium porosum***
14. Ostiole apical 15
14. Ostiole lateral 18
15. Ascomata distinctly pseudostromatic (ascospores 15–27 × 7–10 µm; anthraquinone absent, lichexanthone present) ..... ***Astrothelium phlyctaena***
15. Ascomata solitary to irregularly confluent or diffusely pseudostromatic 16
16. Ascomata solitary to diffusely pseudostromatic; anthraquinone present, lichexanthone absent (ascospores 20–27 × 7–10 µm) ..... ***Astrothelium aeneum***
16. Ascomata solitary to irregularly confluent or crowded; anthraquinone and lichexanthone both absent 17
17. Ascomata sessile, fully exposed, barrel-shaped, black; ascospores 20–25 × 7–10 µm ..... ***Nigrovothelium tropicum***
17. Ascomata erumpent with broad white area surrounding the ostiole or entirely white; ascospores 15–27 × 7–10 µm ..... ***Astrothelium nitidiusculum***
18. Ascospores 20–26 × 7–9 µm; lichexanthone present, anthraquinone absent ..... ***Astrothelium variolosum***
18. Ascospores 23–30 × 6–10 µm; lichexanthone absent, anthraquinone present ..... ***Astrothelium cinnamomeum***
19. Ascospore lumina rectangular to oval at maturity (100–120 × 13–20 µm) ..... ***Bathelium lineare***
19. Ascospore lumina diamond-shaped 20
20. Ostiole apical; hamathecium inspersed with oil droplets; ascospores mostly 4/ascus, 140–220 × 30–75 µm; anthraquinone absent ..... ***Astrothelium megaspermum***
20. Ostiole lateral; hamathecium clear; ascospores 8/ascus, 60–65 × 18–21 µm; anthraquinone present ..... ***Astrothelium subaequans***
21. Ascospores transversely septate 22
21. Ascospores muriform 39
22. Ostiole lateral, pointing in different directions (ascospores 3-septate, 13–18 × 4–6 µm) ..... ***Pyrenula circumfiniens***
22. Ostiole apical 23

23. Ascospores 4–7-septate, with orange oil at maturity (24–32 × 10–15 µm; thallus pseudocyphellate) ..... ***Pyrenula sexlocularis***
23. Ascospores 3-septate 24
24. Ascomata mostly aggregate with fused walls but with separate ostioles (pseudostromatic) (ascospores 15–20 × 6–8 µm) ..... ***Pyrenula anomala***
24. Ascomata mostly single 25
25. Thallus ecorticate (whitish; ascospores 17–25 × 7–11 µm) .. ***Pyrenula microcarpa***
25. Thallus corticate 26
26. Terminal lumina directly against the exospore 27
26. Terminal lumina separated from exospore by thickened endospore wall. 28
27. Hamathecium inspersed with oil droplets; ascospores 16–24 × 8–13 µm ..... ***Pyrenula fetivica***
27. Hamathecium clear; ascospores 17–22 × 9–12 µm ..... ***Pyrenula nitidula***
28. Hamathecium inspersed with oil droplets 29
28. Hamathecium clear 32
29. Ascomata ≤0.7 mm in diam. 30
29. Ascomata>0.7 mm in diam. 31
30. Ascospores 13–15 × 4–6 µm ..... ***Pyrenula laetior***
30. Ascospores 16–22 × 8–10 µm ..... ***Pyrenula subglabrata***
31. Ascospores 15–20 × 4.5–7.5 µm ..... ***Pyrenula mamillana***
31. Ascospores 18–25 × 6–9 µm ..... ***Pyrenula massariospora***
32. Ascospores mostly >25 µm long 33
32. Ascospores mostly <25 µm long 34
33. Thallus pseudocyphellate; ascomata immersed ..... ***Pyrenula quassiicola***
33. Thallus lacking pseudocyphellae; ascomata emergent ..... ***Pyrenula mastophora***
34. Ascospores mostly 21–25 µm long (ascomata <0.5 mm diam.) ... ***Pyrenula nitidella***
34. Ascospores <21 µm long 35
35. Ascospores mostly <15 µm long 36
35. Ascospores mostly>15 µm long 37
36. Ascospores 4–6 µm wide ..... ***Pyrenula aspistea***
36. Ascospores 6–8 µm wide ..... ***Pyrenula brunnea***
37. Ascomata 0.4–0.7 mm in diam. ..... ***Pyrenula aggregata***
37. Ascomata>0.7 mm in diam. 38
38. Lumina round, ascospores 18–22 × 6–9 µm ..... ***Pyrenula scutata***
38. Lumina angular, ascospores 19–22 × 7–8 µm ..... ***Pyrenula balia***
39. Ascomata mostly aggregated with shared ostiole (astrothelioid) (ascospores 100–132 × 32–42 µm) ..... ***Anthracothecium interlatens***
39. Ascomata mostly single 40

40. Ascospores <100 µm long 41
40. Ascospores>100 µm long 47
41. Thallus and ascomata with orange-yellow anthraquinone (ascospores 12–25 × 8–13 µm) ..... ***Pyrenula ochraceoflava***
41. Thallus and ascomata lacking anthraquinone 42
42. Ascospores 12–23 × 8–12 µm ..... ***Pyrenula parvinuclea***
42. Ascospores>25 µm long 43
43. Mature ascospores filled with orange oil (38–50 × 15–20 µm) ....***Pyrenula breutelii***
43. Mature ascospores lacking orange oil 44
44. Hamathecium inspersed with oil droplets (ascospores 30–45 µm long) ..... ***Pyrenula sublaevigata***
44. Hamathecium clear 45
45. Ascospores 60–90 × 30–40 µm ..... ***Anthracothecium prasinum***
45. Ascospores <65 µm long 46
46. Ascospores 33–45 × 11–16 µm ..... ***Pyrenula thelemorpha***
46. Ascospores 45–65 × 15–25 µm ..... ***Pyrenula pyrenuloides***
47. Thallus pseudocyphellate; ascospores 2 per ascus, 110–180 × 30–45 µm ..... ***Pyrenula duplicans***
47. Thallus non-pseudocyphellate; ascospores 1–4 per ascus, 120–160 × 30–45 µm ..... ***Anthracothecium macrosporum***

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